Introduction to the NIST Center for Neutron Research (NCNR)

Modern technological society is dependent upon increasingly sophisticated use of materials with attributes dictated by their sub-microscopic structural and dynamical properties. A wide range of techniques provides knowledge of these properties. Scattering probes (for example: x-rays, light, electrons, neutrons) are arguably the most important. Of these probes, neutrons are perhaps least familiar, but they provide important advantages for many types of measurements.

Modern sources provide neutrons moving at speeds comparable to those of atoms at room temperature, thus providing the ability to probe dynamical behavior. Neutrons are also well matched to probe lengths ranging from the distances between atoms to the size of biological or polymer macromolecules. Neutrons are sensitive to the magnetic properties of atoms and molecules, allowing study of the underlying magnetic properties of materials. They also scatter differently from normal hydrogen atoms than they do from heavy hydrogen (deuterium), allowing selective study of individual regions of molecular systems. Finally, neutrons interact weakly with materials, providing the opportunity to study samples in different environments more easily (at high pressures, in shear, in reaction vessels, etc.), and making them a non-destructive probe. These favorable properties are offset by the weakness of the best neutron sources compared to x-ray or electron sources, and by the large facilities required to produce neutrons. As a result, major neutron sources are operated as national user facilities to which researchers come from all over the United States and abroad to perform small-scale science using the special measurement capabilities provided.

In addition to scattering, neutrons can be captured by nuclei to probe the atomic composition of materials. The subsequent characteristic radioactive decays provide "fingerprints" for many atomic nuclei, allowing studies of environmental samples for pollutants (e.g., heavy metals), characterization of Standard Reference Materials, and other measurements. There are important areas in physics that can be explored by measuring fundamental neutron behavior. Examples include the lifetime of the free neutron, important for the theory of astrophysics; the neutron beta decay process, that provides a stringent test of nuclear theory; and the effects of various external influences such as gravity or magnetic fields on neutrons.

The NCNR's 20-MW NIST Research Reactor provides a national user community with facilities, including the nation's only internationally competitive cold neutron facility, for all of the above types of measurements. There are about 35 stations in the reactor and its associated beams that can provide neutrons for experiments. At the present time 28 of these are in active use, of which 6 provide high neutron flux positions in the reactor for irradiation, and 22 are beam facilities. The following pages show a schematic layout of the facility. More complete descriptions of instruments can be found at http://www.ncnr.nist.gov.

These facilities are operated both to serve NIST mission needs and as a national facility, with many different modes of access. Some instrumentation was built years ago, and is not suited to general user access; however, time is available for collaborative research. NIST has recently built new instrumentation, and reserves 1/3 of available time for mission needs with the balance available to general users. In other cases, instrumentation was built and is operated by Participating Research Teams (PRT); PRT members have access to 75 % of available time, with the balance available to general users. Additionally, NIST and the National Science Foundation operate the Center for High Resolution Neutron Scattering at the NCNR, with one thermal and five cold neutron instruments. For these facilities, most time is available for general users. While most access is for research, with results that are freely available to the general public, proprietary research can be performed under full cost recovery. Each year, about 1600 researchers (persons who participated in experiments at the facility, but did not necessarily come here) from all areas of the country, from industry, academia, and government use the facility for measurements not otherwise possible. The research covers a broad spectrum of disciplines, including chemistry, physics, biology, materials science, and engineering.